# Timberland Inventory Characteristics

Knowledge of growing stock volume, measured by the bole wood of forest trees greater than five-inch diameter at breast height (DBH), and how it changes in response to natural disturbances and management activities is central to considerations of sustainable wood product use by industry. See the online document 2003 National Report on Sustainable Forests (U.S. Forest Service, 2002a).

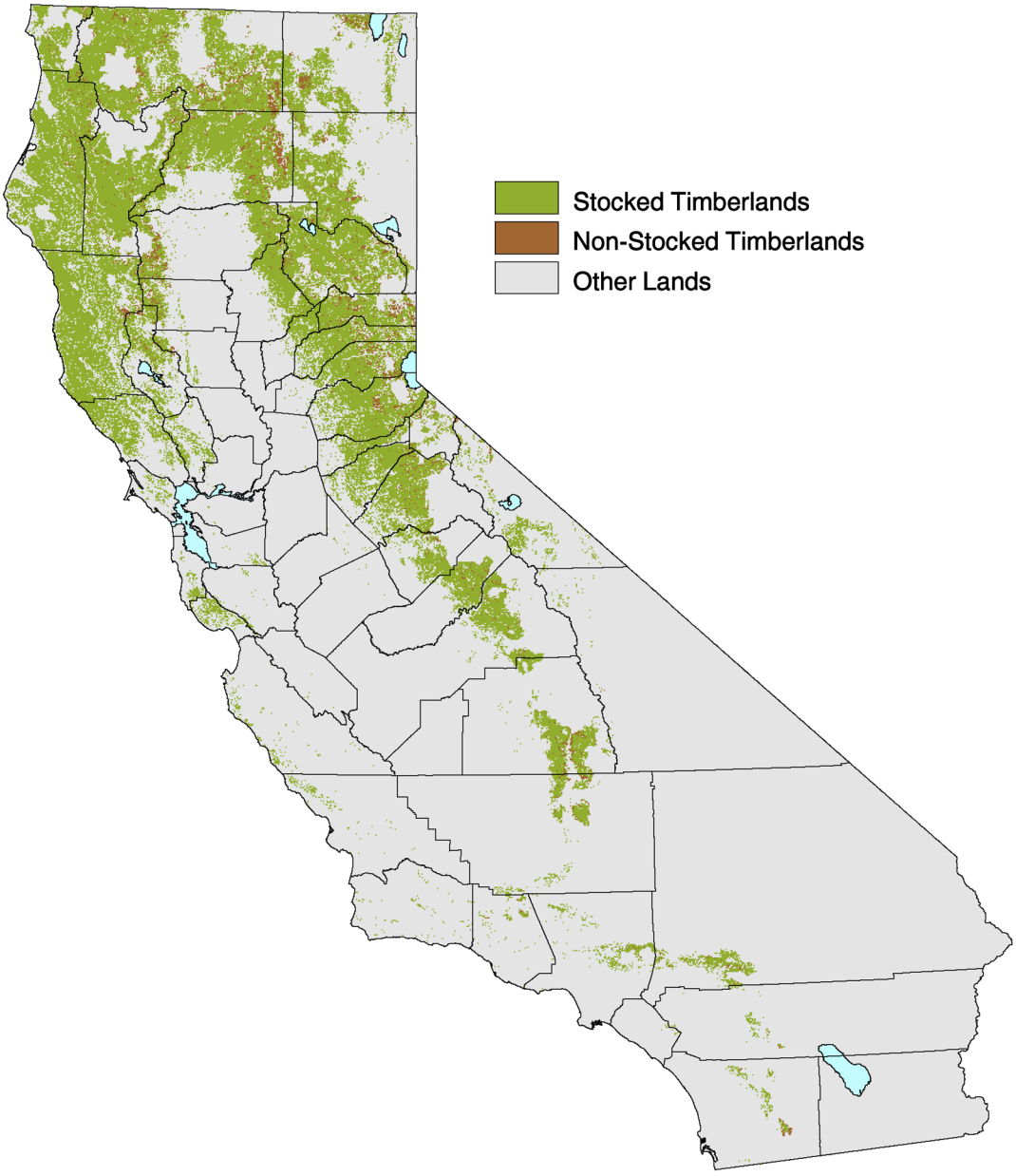
This section concentrates on the volume of timberland growing stock. Timberlands are a subset of the forest land base and are lands available and capable of growing at least 20 cubic feet of industrial wood per acre, per year. Timberlands are the focus of this analysis since they are the portions of all forest lands that produce the lumber, pulp, and biomass products used for local consumption and export.


*Evenaged timberlands.*

In 1994, California's " timberland inventory" or volume of growing stock on timberland, consisted of a net volume of approximately 55 billion cubic feet. This growing stock included both softwood and hardwood trees from five inches DBH to old growth trees several feet in diameter. The term "net volume of growing stock," is the most inclusive estimate of tree volume since it measures the volume of all standing trees. The concept refers to the bole volume of non-cull trees, minus deduction for rot and/or missing portions of the bole (cull trees are those completely rotted or defected).

**Estimating tree volumes:** Tree volume estimates are specified in "cubic feet." This unit of measurement is used because it refers to the total bole wood biomass of the tree. Other units such as board feet (a section of lumber that is 12 inches wide by one inch thick by 12 inches long) only measure lumber produced from a tree. Furthermore, the concept of board feet does not include volume from trees less than nine inches DBH (diameter at breast height) or non-lumber wood products such as pulp and chips that can be produced from smaller trees. While board feet volume is a traditional measure of lumber (California's dominant wood product), utilization practices and management constraints are resulting in a shift towards the use of smaller trees.

Figure 1. Approximate locations of timberlands in California



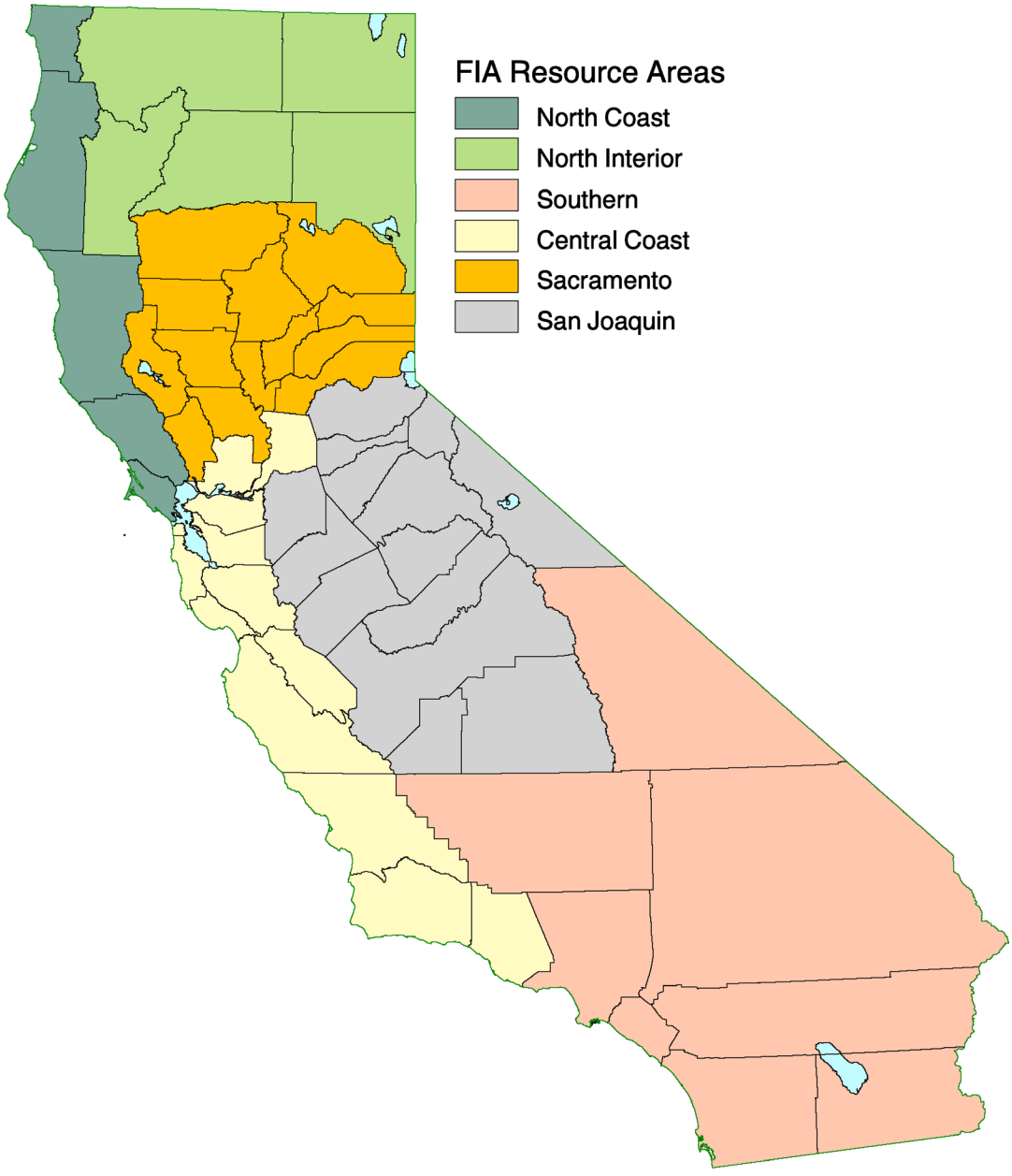

*Source: Fire and Resource Assessment Program (FRAP), 2002*

The primary source of information for timberlands statistics is the Forest Inventory and Analysis (FIA) conducted by the Pacific Northwest Research Station (PNW) of the U.S. Forest Service (USFS). Prior to 2000, the FIA was conducted every decade as part of the national mandate authorized by the Forest and Rangeland Renewable Resource Research Act of 1978. Beginning in 2001, the FIA began collecting data annually rather than once per decade. The FIA is a plot-based, field survey and statistical analysis of all forest lands outside the system. The most recent set of complete forest statistics reported in the FIA was collected from 1991 through 1994 and is referred to as the 1994 reporting period. The survey and analysis was published in 1997 in a series of publications called "Timber Resource Statistics for Resource Areas of California". See the online document California publications abstracts and summaries and FIA Timber Resource Statistics (USFS, 2002b) for more information. For an in-depth discussion of

FIA sampling statistics and geographic scope, see the Assessment document FIA Sampling Methods and Resource Areas.

FIA statistics are collected and reported for six resource areas—North Coast, Central Coast, North Interior, Sacramento, San Joaquin, and Southern regions (Figure 2). Throughout this paper, the regional information provided is defined by these resource areas following county boundaries.

Figure 2. FIA resource areas and county boundaries




*Source: Waddell and Bassett, 1996, 1997a, 1997b, 1997c, 1997d*

## Findings on growing stock volume by ownership and resource area

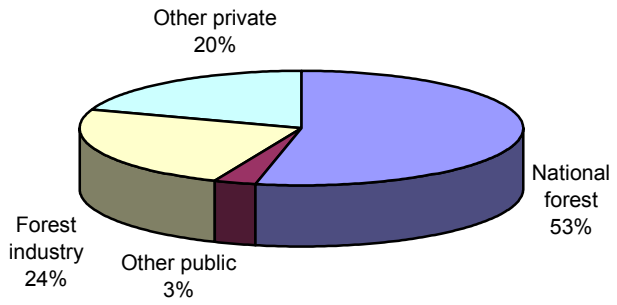
In 1994, 53 percent (29 million cubic feet) of the total net volume of growing stock on California timberlands existed in national forest resource areas, 24 percent (13.3 million cubic feet) existed in forest industry areas, 20 percent (10.8 million cubic feet) in other private, and the remaining three percent (1.6 million cubic feet) in other public (Table 1 and Figure 3).

Table 1. Volume of growing stock on timberlands by ownership, 1994 (thousand cubic feet)

| National forest | Other public | Forest industry | Other private | All owners |
|---|---|---|---|---|
| 29,310,573 | 1,639,412 | 13,282,544 | 10,787,039 | 55,019,563 |

*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

Figure 3. Percentage volume of growing stock on timberlands by owner




*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

The distribution of total growing stock varies by region and ownership. Over 80 percent of the growing stock in the State is found in three northern California resource areas (Table 2). The North Interior (Klamath Mountains, northern Sierra Nevada Mountains, and Modoc Plateau) contains the largest holdings of growing stock with over 17.2 billion cubic feet (31 percent of the State total), the Sacramento resource area (Sierra Nevada Mountain counties from El Dorado to Plumas and other western Sacramento Valley counties) contains 13.8 billion cubic feet (25 percent of the State total), and the North Coast resource area (northern California coast counties from Sonoma to Del Norte) contains 13.6 billion cubic feet (25 percent of the State total).

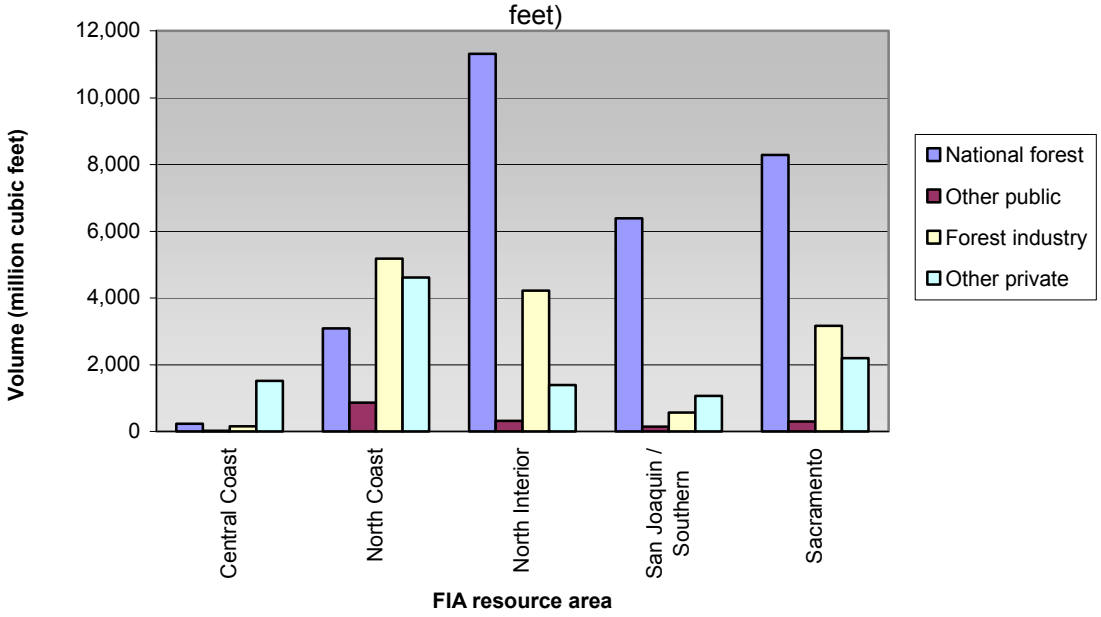
Ownership also varies by region (Table 2). National forests contain a majority of growing stock in the North Interior, Sacramento, and the combined San Joaquin/Southern resource areas. Forest industry contains the largest holdings in the North Coast and substantial holdings in the North Interior. Other private is the predominant ownership category in the Central Coast. Figure 4 illustrates the relationship between growing stock volume by ownership and resource area.

Table 2. Net volume of growing stock on timberlands by owner, 1994 (thousand cubic feet)

| Region | National forest | Other public | Forest industry | Other private | All owners |
|---|---|---|---|---|---|
| California | 29,310,573 | 1,639,412 | 13,282,544 | 10,787,039 | 55,019,563 |
| Central Coast | 228,981 | 19,586 | 156,316 | 1,514,826 | 1,919,708 |
| North Coast | 3,086,499 | 867,829 | 5,178,525 | 4,615,143 | 13,747,997 |
| North Interior | 11,313,238 | 313,526 | 4,220,802 | 1,390,858 | 17,238,422 |
| San Joaquin/Southern | 6,390,792 | 140,467 | 562,345 | 1,068,030 | 8,161,636 |
| Sacramento | 8,291,063 | 298,004 | 3,164,556 | 2,198,182 | 13,951,799 |

*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

Figure 4. Volume of timberland growing stock by ownership and FIA resource area, 1994 (million cubic feet)




*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

## Findings on historical trends in inventory volume

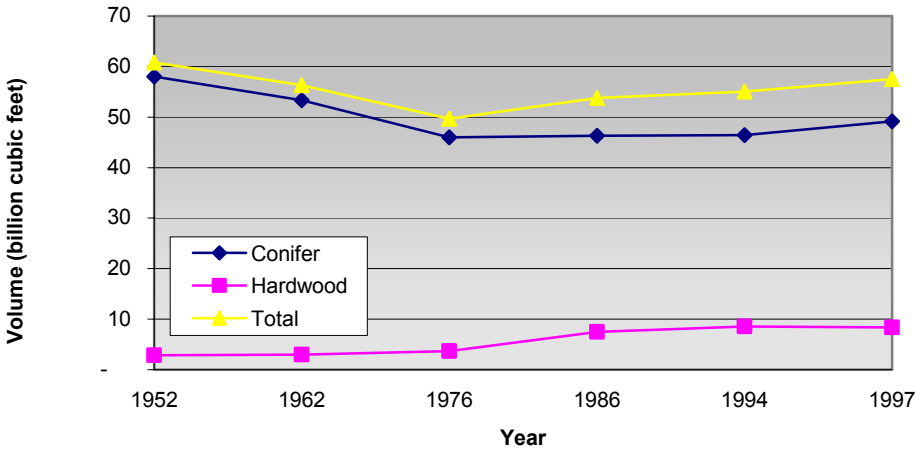
***During the most recent measurement period (1977 to 1997), the net volume of growing stock increased by 16 percent.***

On a statewide basis, total inventories were declining until the mid-1970s when the net growth of second growth forests surpassed total harvests. The net volume of growing stock declined by 18 percent across all ownerships between 1952 and 1977, but increased by 16 percent to 57 billion cubic feet from 1977 to 1997 (Figure 5). During the most recent decadal measurement period (1984 to 1994), the net volume of growing stock increased 11 percent.

The current net volume of growing stock consists of a higher proportion of hardwood in 1997 as compared to earlier years. Statewide, hardwood volume climbed from five percent net volume of growing stock in 1952 to 16 percent in 1997 (Table 3). While the proportion of hardwoods increased across all ownerships, most of the increases occurred on private lands. Hardwood proportion of total volume increased four-fold on forest industry and three-fold on other private timberland from 1952 to 1997. This increase in hardwoods could be due to the rising frequency of conifer forest destruction by wildfire, the

absence of conifer regeneration after wildfires, and logging practices that result in unsuccessful regeneration of conifer trees.

Figure 5. Net volume of conifer and hardwood growing stock on timberland, statewide, 1952 to 1997




*Source: 1994 data compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d; All other years: Smith et al., 2001*

Table 3. Net volume of softwood and hardwood growing stock on timberland, Statewide, 1953 and 1997 (million cubic feet)

| Owner | Forest type | 1952 | Percentage of 1952 total volume | 1997 | Percentage of 1997 total volume | Percentage change in volume, 1952 to 1997 |
|---|---|---|---|---|---|---|
| National forest | Softwood | 29,590 | 49 | 29,539 | 51 | <1 |
| | Hardwood | 1,276 | 2 | 2,264 | 5 | 77 |
| Other public | Softwood | 1,892 | 3 | 1,320 | 2 | -30 |
| | Hardwood | 218 | <1 | 319 | <1 | 46 |
| Forest industry | Softwood | 11,268 | 19 | 8,592 | 20 | -24 |
| | Hardwood | 336 | 1 | 1,701 | 4 | 406 |
| Other private | Softwood | 15,256 | 25 | 9,716 | 14 | -36 |
| | Hardwood | 998 | 2 | 4,054 | 7 | 306 |
| Total by forest type | Softwood | 58,006 | 95 | 49,167 | 84 | -15 |
| | Hardwood | 2,828 | 5 | 8,337 | 16 | 194 |
| Total all types | | 60834 | 100 | 57,504 | 100 | -6 |

*Source: compiled by FRAP from Smith et al., 2001*

## Findings on timberland volume by species and forest type

The individual tree species listed in Table 4 indicate the net volume of trees with the same species name regardless of the type of forest in which they are found. These species are often mixed within a forest stand to create forest types (Figure 6 and Table 5).

### Timberland volume by species

The most prominent tree species by net volume of growing stock are Douglas-fir (24 percent of Statewide total volume), white fir (16 percent), ponderosa pine (11 percent), and redwood (9 percent).

Table 4. Volume of timberland growing stock by species and ownership, 1994 (million cubic feet)

| Species | National forests | Other public | Forest industry | Other private | Total |
|---|---|---|---|---|---|
| **Softwoods** | | | | | |
| White fir | 6,436 | 141 | 2,054 | 461 | 9,091 |
| Grand fir | 0 | 12 | 92 | 39 | 142 |
| California red fir | 2,686 | 3 | 398 | 58 | 3,145 |
| Port-Orford cedar | 38 | 0 | 3 | 3 | 43 |
| Incense cedar | 1,447 | 44 | 672 | 482 | 2,644 |
| Sitka spruce | 0 | 0 | 0 | 36 | 36 |
| Brewer spruce | 16 | 0 | 0 | 0 | 16 |
| Whitebark pine | 12 | 0 | 2 | 0 | 13 |
| Knobcone pine | 19 | 2 | 21 | 7 | 49 |
| Bristlecone pine | 1 | 0 | 0 | 0 | 1 |
| Lodgepole pine | 598 | 15 | 59 | 90 | 762 |
| Coulter pine | 24 | 0 | 0 | 6 | 31 |
| Foxtail pine | (L) | 0 | 0 | 0 | (L) |
| Limber pine | 3 | 0 | 0 | 0 | 3 |
| Sugar pine | 1,892 | 37 | 660 | 184 | 2,772 |
| Bishop pine | 0 | 10 | 11 | 35 | 56 |
| Jeffrey pine | 1,985 | 65 | 201 | 330 | 2,580 |
| Ponderosa pine | 3,504 | 131 | 1,434 | 1,097 | 6,165 |
| Western white pine | 210 | 0 | 26 | 13 | 249 |
| Bigcone Douglas-fir | 0 | 0 | 0 | 15 | 15 |
| Monterey pine | (L) | 0 | 1 | 42 | 43 |
| Douglas-fir | 7,614 | 384 | 2,970 | 2,655 | 13,622 |
| Redwood | 126 | 474 | 2,495 | 1,627 | 4,721 |
| Giant sequoia | 33 | 0 | 1 | 4 | 39 |
| Western redcedar | 0 | 0 | 1 | 0 | 1 |
| California-nutmeg | 0 | 4 | 5 | (L) | 9 |
| Western hemlock | (L) | 3 | 18 | 10 | 31 |
| Mountain hemlock | 171 | 0 | 0 | 0 | 171 |
| Other softwoods | 1 | 0 | 0 | 0 | 1 |
| Total | 26,816 | 1,325 | 11,124 | 7,194 | 46,451 |
| **Hardwoods** | | | | | |
| Bigleaf maple | 19 | 8 | 52 | 86 | 165 |
| Red alder | 8 | 0 | 118 | 97 | 221 |
| White alder | 16 | 0 | 20 | 11 | 46 |
| Pacific madrone | 355 | 55 | 264 | 598 | 1,272 |
| Giant chinkapin | 19 | 0 | 11 | 15 | 45 |
| Eucalyptus | 0 | 0 | 4 | 16 | 19 |
| Oregon ash | 5 | 2 | 0 | 1 | 7 |
| Walnut | 0 | 0 | 0 | 1 | 1 |
| Tanoak | 387 | 36 | 890 | 855 | 2,167 |
| Quaking aspen | 7 | 0 | 2 | 14 | 24 |
| Sycamore | (L) | 0 | 0 | 0 | (L) |
| Black cottonwood | (L) | 1 | 1 | 10 | 13 |
| Fremont cottonwood | 0 | 0 | 0 | 1 | 1 |
| Coast live oak | 6 | 0 | 4 | 131 | 140 |
| Canyon live oak | 607 | 117 | 281 | 376 | 1,379 |
| Blue oak | 7 | 0 | 0 | 4 | 11 |
| Oregon white oak | 12 | 13 | 16 | 204 | 245 |
| California black oak | 1,005 | 79 | 426 | 911 | 2,420 |
| Valley white oak | 0 | 00 | 0 | 26 | 26 |
| Valley oak | 15 | 0 | 0 | 9 | 23 |
| Interior live oak | 22 | 2 | 14 | 31 | 70 |
| California-laurel | 4 | 6 | 60 | 202 | 272 |
| Other hardwoods | 6 | 0 | 0 | 0 | 6 |
| Total | 2,500 | 319 | 2,163 | 3,599 | 8,573 |
| All species | 29,316 | 1,644 | 13,287 | 10,793 | 55,024 |

*(L) – less than 500 acres*

*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

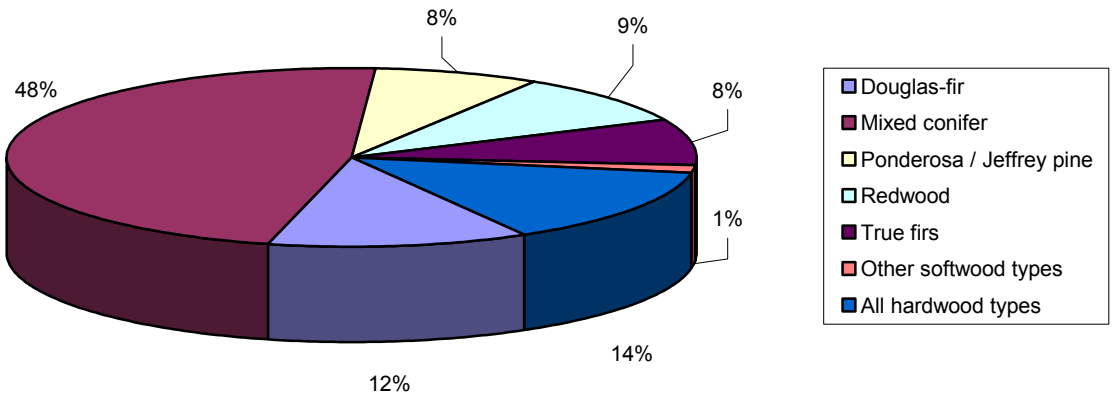
## Timberland volume by forest type

The term forest type refers to the dominance of a tree species within a forest stand. When more than 70 percent of a stand is comprised of a particular species, it is classified as a pure hardwood or softwood type and assigned the type name of the dominant species. Mixed stands (those containing several tree species) are assigned type names reflecting the multiple species present. Forest type is the major indicator of the likely silvicultural practice, commodity value, wildlife habitat, and ecological attributes within the forest stand.

Softwood forest types (stands dominated by coniferous tree species, usually evergreen with needle-like leaves) dominate California's timberlands across all ownerships. Approximately 86 percent of the net volume of growing stock on California timberlands is composed of softwood forest types while hardwood types comprise 14 percent. The forest types on timberlands have been grouped into seven general categories (Figure 6), and a detailed listing of timberland growing stock volume by forest type is included in Table 5. The mixed conifer forest type is the most dominant, comprising nearly half of all timberland volume. Mixed conifer include various combinations of sugar pine, ponderosa pine, Jeffery pine, incense cedar, Douglas-fir, white fir, and red fir. Mixed conifer is found in every FIA resource area in the State and is the predominant type found in the North Interior, Sacramento, and San Joaquin resource areas.

***Approximately 86 percent of the net volume of growing stock on California timberlands is composed of softwood forest types while hardwood types comprise 16 percent.***

Figure 6. Percentage volume of timberland by forest type, 1994




*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

Table 5. Volume of timberland by forest type and ownership, 1994 (million cubic feet)

| Forest type | National forest | Other public | Forest industry | Other private | All owners |
|---|---|---|---|---|---|
| **Softwood types** | | | | | |
| Douglas-fir | 4,616 | 147 | 548 | 1,399 | 6,710 |
| Mixed conifer | 16,902 | 438 | 5,961 | 2,530 | 25,830 |
| Ponderosa/ Jeffery pine | 2,901 | 81 | 567 | 669 | 4,217 |
| Redwood | 127 | 633 | 2,763 | 1,565 | 5,086 |
| True firs | 3608 | 64 | 790 | 79 | 4540 |
| Other softwood types | 450 | 17 | 99 | 192 | 759 |
| *Total, softwood types* | 28,602 | 1,381 | 10,728 | 6,432 | 47,140 |
| *Total, hardwood types* | 490 | 258 | 2,540 | 4,338 | 7,625 |
| *Total, Nonstocked* | 220 | 1 | 18 | 19 | 256 |
| Total, all types | 29,311 | 1,641 | 13,283 | 10,787 | 55,021 |

*Note: area of softwood types includes mixed conifer-hardwood types*

*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

Concerns over forest composition include desires for more diverse forests and changing species compositions resulting from harvest practices, fire suppression, regulatory impediments to intensive timber management. The changes are causing a shift to shade tolerant species, such as true firs, incense-cedar and some hardwoods, and declines in commercially preferred pine forests that support more open understories. Summarized evidence from several historical field plot studies suggests a changing forest composition towards more shade tolerant species, particularly in the Sierra and Modoc bioregions (Helms and Tappeiner, 1996; Centers for Water and Wildland Resources, 1996; U.S. General Accounting Office, 1999; Bonnickson and Stone, 1981; Parsons and DeBenedetti, 1979). Additional information from the USDA Forest Service Forest Inventory and Analysis (FIA), documented as part of the national Resource Planning and Assessment (Smith et al., 2001), indicates substantially increased levels of hardwoods as a percentage of total volume, slightly declining volumes of shade intolerant pine species, stable levels of shade tolerant true fir, and increasing levels of shade tolerant incense-cedar (Table 6).

When combined with trends of increasing stocking levels, high levels of understory trees serve as ladder fuels and raise the risk of unnaturally severe fires. Additional effects involve increased mortality and pests, and decline in commercial species growth rates.

Table 6. Net volume of growing stock on timberland in the Pacific Southwest (California and Hawaii) region by species (million cubic feet), 1963, 1977,1987, and 1997

| Species | 1963 | 1977 | 1987 | 1997 |
|---|---|---|---|---|
| | Million cubic feet | | | |
| Softwoods | | | | |
| Douglas-fir | 17,277 | 12,786 | 12,700 | 13,898 |
| Ponderosa and Jeffrey pine | 10,210 | 9,124 | 8,695 | 9,722 |
| True fir | 13,428 | 12,804 | 12,689 | 13,346 |
| Western hemlock | 69 | 129 | 42 | 31 |
| Sugar pine | 3,694 | 3,355 | 3,031 | 2,960 |
| Western white pine | 305 | 231 | 319 | 276 |
| Redwood | 5,352 | 4,302 | 5,114 | 4,610 |
| Sitka spruce | 33 | 48 | 36 | 0 |
| Engelmann and other spruces | 0 | 7 | 14 | 36 |
| Incence-cedar | 1,699 | 2,004 | 2,365 | 2,849 |
| lodgepole pine | 903 | 870 | 861 | 911 |
| Other softwoods | 395 | 319 | 445 | 534 |
| Total softwoods | 53,365 | 45,979 | 46,311 | 49,172 |
| Hardwoods | | | | |
| Cottonwood and aspen | 41 | 21 | 20 | 35 |
| Red alder | 61 | 64 | 133 | 218 |
| Oak | 892 | 1,796 | 5,728 | 4,320 |
| Other hardwoods | 2,200 | 2,010 | 1,863 | 4,041 |
| Total hardwoods | 3,194 | 3,891 | 7,744 | 8,613 |
| | | | | |
| All species | 56,559 | 49,870 | 54,055 | 57,785 |

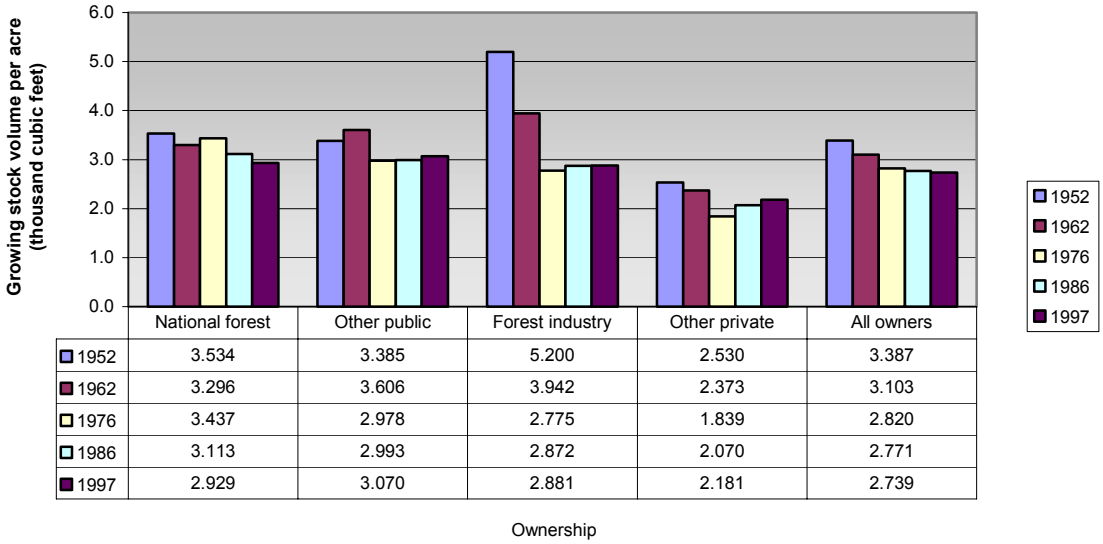
*Source: compiled by FRAP from Smith et al., 2001*

## Findings on timberland volume per acre

### Historical trends in volume per acre

Trends in ownership and class-specific growing stock volumes per acre illustrate the combined trends of volume, density, and area. The most recent report as required by the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA) provides comparable historical volume and area data across the four major ownership classes (Smith et al., 2001). Changes in both sampling and land base classification methods are responsible for some of the differences, especially on national forest lands where large acreages have moved between timberland and non-timberland classes. However, the overall comparison and trend are illustrative (Figure 7).

Figure 7. Volume of timberland growing stock per acre, all forest types, by owner group, 1952 to 1997 (thousand cubic feet)




| | National forest | Other public | Forest industry | Other private | All owners |
|---|---|---|---|---|---|
| 1952 | 3.534 | 3.385 | 5.200 | 2.530 | 3.387 |
| 1962 | 3.296 | 3.606 | 3.942 | 2.373 | 3.103 |
| 1976 | 3.437 | 2.978 | 2.775 | 1.839 | 2.820 |
| 1986 | 3.113 | 2.993 | 2.872 | 2.070 | 2.771 |
| 1997 | 2.929 | 3.070 | 2.881 | 2.181 | 2.739 |

Ownership

*Source: compiled by FRAP from Smith et al., 2001*

For all owners, the average volume per acre declined from the 1950s through the 1970s but has been relatively stable since. This trend was most noticeable in forest industry lands as old growth stands were harvested and regenerated with rapidly growing younger trees and forest stands. Based on RPA areas and volume, all ownerships except national forests exhibited increasing volumes per acre since 1976. The continued decline in average volume per acre on national forests may be primarily due to the acreage changes included in the calculations. Recent national forest inventory data based on constant area suggests increasing volumes on national forest lands. For example, 1994 FIA reports using measurement techniques similar to the previous period's sampling methods showed total volume at over 3,336 cubic feet per acre. This finding suggests increasing volume per acre on national forest land since 1986. Additionally, measurements taken on national forest timberland in 2000 revealed higher volume levels than the 1997 estimates (Table 7).

**Recent estimates of volume per acre:** FIA reported updated volume per acre statistics by forest type and size class for national forests lands in 2000 (Warbington and Beardsley, 2001) (see Table 7). When compared to 1994 information on national forests, volume per acre statistics shows a 1.8 percent increase (3,336 to 3,396 cubic feet per acre) over the last 10-year monitoring period.

Table 7. Volume per acre of timberland on national forest land, 2000 (cubic feet)

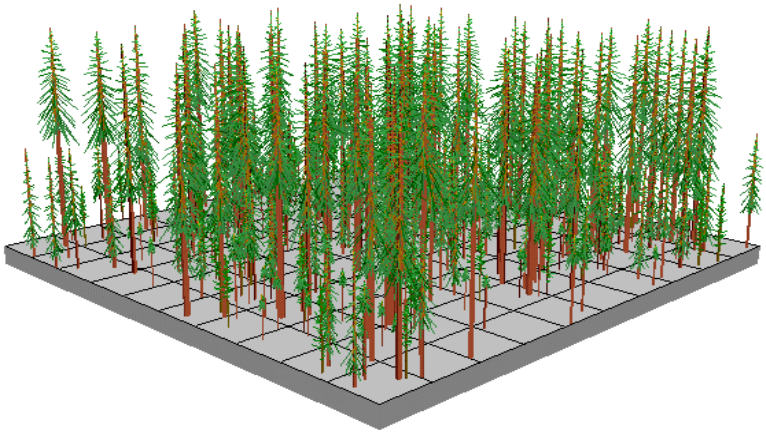
| | National forest |
|---|---|
| Total volume per acre, softwoods | 3,035 |
| Total volume per acre, hardwoods | 349 |
| Total | 3,396 |

*Source: Warbington and Beardsley, 2001*

## Findings on stand structure in California

Information found in the FIA summarizes acreage according to unevenaged and evenaged stand structures. By definition, evenaged stands are those in which 70 percent or more of the timberland growing stock falls within three adjacent 10-year age classes. Conversely, unevenaged stands are those that contain less than 70 percent of growing stock in three adjacent 10-year age classes. Evenaged stands are usually characterized as those in which the trees are of equal height and which are relatively homogenous in species composition. Figure 8 depicts the structure of an evenaged forest.

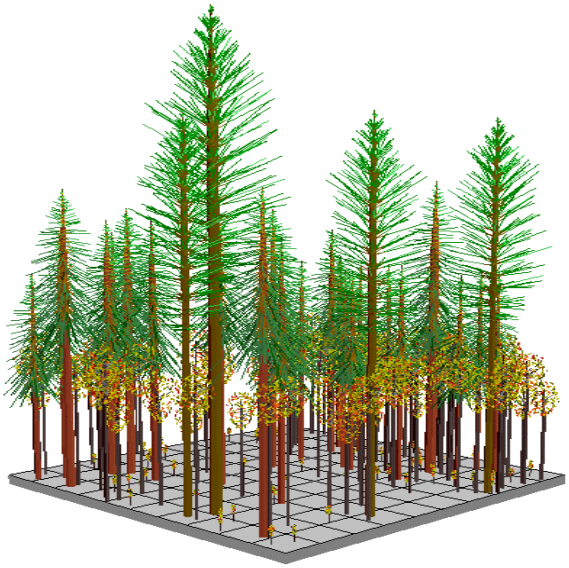
Figure 8. Evenaged forest structure



*Source: Shih, 1999*

Unevenaged stands possess a variety of different tree sizes and ages, usually with many smaller trees transitioning in size to a few large trees. Figure 9 depicts the characteristics of a forest with an unevenaged structure.

Figure 9. Unevenaged forest structure



*Source: Shih, 1999*

While California forests are biologically capable of naturally producing both evenaged and unevenaged stands, timberland statistics show a predominance of evenaged stands (nearly 78 percent). However, national forests are not evaluated according to even or unevenaged classification and are indiscriminately classified as evenaged.

Evenaged forest stands are the predominant stand structure in the State's timberlands for a variety of reasons. Disturbance regimes that result in evenaged stands (fire, flood, windthrow, pest damage) are natural processes that shape many of the forests (Burns, 1989). Management practices, including harvesting and the burning of the forest understory by early Native Americans, transformed and maintained some forest stands as evenaged structures. Finally, evenaged management has been used by some timberland owners where it has met both their harvest and regeneration goals.

From a forest management perspective, the preferred commercial species in the State (redwood, Douglas-fir, and pine) are "shade intolerant species," or those that grow best in full sunlight. Recent fieldwork has shown that the opening as a small as quarter acres can meet regeneration requirements of these species. Modern harvesting and regeneration practices since the 1950s have concentrated on these more valuable species. Earlier silvicultural and reforestation efforts cleared the land of all vegetation through clear cutting and site preparation and then replanted preferred species, creating large evenaged areas. Additionally, early railroad logging practices resulted in heavily logged lands consisting of non-desirable species and small trees. These lands evolved into two-storied, evenaged stands where natural regeneration was the primary reforestation method within these stands (typical of the Sierra Nevada bioregion), and shade-tolerant, understory trees (white fir, incense cedar) have become a major component. Currently, California's forest practice regulations limit most newly created even aged openings created by clearcutting to 30 acres or less, far smaller sizes than other Pacific states and Canada.

The evolution of uneven stands is primarily the result of the following three dynamics: 1) forest stand locations not influenced by disturbance; 2) ownership preference for multistoried stands; and 3) post 1950 fire suppression efforts (excluding disturbance stands) and the removal of understory, shade tolerant trees. However, the current picture (1994) shown in the following discussion of the proportions of timberland volume in unevenaged classifications is somewhat limited by differences in protocols used on national forest lands in which all stands were classified as evenaged.

Over coming decades, it is possible that use of clearcutting or other evenaged systems may increase somewhat in the Sierra in stand conditions where current growth is below potential due to past harvesting and wildfire suppression efforts. In many stands, the practice of high grading removed most of the valuable pines and larger trees of all species and left diminished vigor in the remaining stand. This harvesting practice, together with successful wildfire suppression efforts, often caused stand composition to shift to less economically valuable species such as white fir and incense cedar. Many stands, especially in the Sierra, are in this condition and some land managers are considering the use of clearcutting or similar techniques to regenerate the stands to achieve better use of the site for desired tree species.

Forest managers are also considering other techniques such as variable retention, mixed evenaged, and small group selection that can achieve similar productivity levels while simultaneously achieving other desired goals of wildlife habitat, visual aesthetics, and harvesting intensity. Variable retention has been increasingly used in the Pacific Northwest and British Columbia, and involves retaining the structural elements of the harvested stand for at least a full rotation. This harvesting method is flexible and can lead to evenaged, multi-aged, or unevenaged stands. The spatial pattern of the retained trees may follow stream courses, focus on unique wildlife habitats, or be spread throughout the stand.

***Variable retention is a silvicultural system where a variable amount (percentage) of the original old growth structure is retained in a given harvest area.***

**Emerging stand structures emphasizing ecosystem needs—variable retention system:** Creating forests that emphasize ecosystem management and that promote the tree compositions and arrangements needed to support biodiversity are a primary goal of western U.S. and Canadian forest managers. To achieve these goals, researchers and forest mangers are adopting "silvicultural prescriptions" or tree management practices that preserve residual trees and structural components such as snags. These practices maintain a functional habitat for wildlife that use the forest.

*Variable retention harvest prescription in British Columbia.*

One such system originating out of forest practice operations in British Columbia is called "variable retention" (Canadian Ministry of Forests, 2001). Variable retention is a silvicultural system designed to accomplish two objectives: 1) retain individual trees or groups of trees in order to maintain structural diversity over the area of the harvest unit for at least one harvest rotation; and 2) ensure that more than half the total area of the cutblock exists within one tree height from the base of any tree or group of trees, whether or not the tree or group of trees is inside the cutblock. The image above is an example of variable retention in use on Weyerhauser Corporation Crown lands.

Unlike typical silvicultural systems, named after the primary method of regeneration, the objective of the variable retention system is to retain structural elements of the existing stand over the harvested area for at least one rotation. It recognizes the role of structural complexity in forest ecosystem function and biological diversity. The system also provides a range of retention that may be prescribed while still meeting its criteria.

Variable retention systems follow nature's model by retaining part of the forest after harvest. Research has shown that structural complexity is important to forest ecosystem maintenance. In certain situations, this retention of parts of the forest suggests small clumps or individual mature trees scattered over the entire harvest area while in others, it might require multiple harvesting passes over the same area spanning many years, eventually removing most trees. The system's purpose is to address a wider array of forest management goals as an alternative to conventional systems that tend to focus on economic harvest returns along with the regeneration and growth of the next crop of trees. It attempts to optimize a mix of forest values at the stand level without maximizing any single resource such as productivity (Canadian Ministry of Forests, 2001).

*Variable retention silviculture in Jackson Demonstration State Forest*

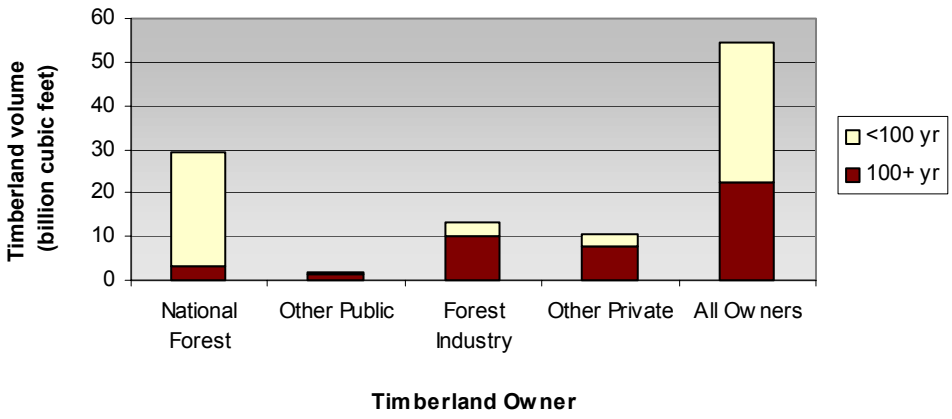
## Findings on timberland volume by age class

The current distribution of timberland volume is based on the average stand age, as determined by USFS field crews. These studies provide considerable information on what has occurred within timberlands over the past decades as well as what timberlands will look like in decades to come. As mentioned, the picture (as of 1994) is somewhat limited by differences in protocols used on national forest lands in which all stands were classified as evenaged. It logical to believe that the next FIA measurement period, due begging in 2005, will show substantial portions of the USFS lands to have unevenaged characteristics, resulting from standardization of measurement protocols.

***Over 58 percent of the total growing stock volume exists in stands greater than 100 years of age.***

By grouping age class information from Table 8 into century age class groupings, a broad perspective emerges with regard to California's timberland volume across age class distribution (including both even and unevenaged stands). As shown in Figure 10, over 58 percent of the total growing stock volume exists in stands greater than 100 years of age.

Figure 10. Volume of timberland by ownership and age class




*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

Table 8. Net volume of growing stock on timberlands by owner and age class (thousand cubic feet)

| Age class | National forest | Other public | Forest industry | Other private | All owners |
|---|---|---|---|---|---|
| Evenaged | | | | | |
| 0-9 | 18,271 | 16,770 | 32,851 | 35,364 | 103,256 |
| 10-19 | 210 | 5,751 | 63,989 | 24,835 | 94,785 |
| 20-29 | 25,040 | 2,663 | 226,805 | 53,324 | 307,830 |
| 30-39 | 50,127 | 68,688 | 606,523 | 613,425 | 1,338,763 |
| 40-49 | 11,594 | 3,131 | 856,391 | 600,068 | 1,471,185 |
| 50-59 | 196,430 | 151,193 | 1,172,255 | 795,250 | 2,315,128 |
| 60-69 | 12,057 | 41,874 | 1,322,562 | 697,995 | 2,074,488 |
| 70-79 | 579,440 | 240,159 | 1,017,757 | 731,790 | 2,569,146 |
| 80-89 | 563,574 | 126,266 | 447,102 | 749,610 | 1,886,551 |
| 90-99 | 1,960,876 | 48,541 | 323,014 | 817,448 | 3,149,880 |
| 100-109 | 3,409,134 | 15,969 | 201,314 | 370,069 | 3,996,484 |
| 110-119 | 2,242,690 | 0 | 128,484 | 85,564 | 2,456,738 |
| 120-129 | 4,532,695 | 0 | 0 | 27,055 | 4,559,750 |
| 130-139 | 1,727,875 | 0 | 72,535 | 10,054 | 1,810,463 |
| 140-149 | 1,930,174 | 0 | 0 | 0 | 1,930,174 |
| 150-159 | 3,330,985 | 0 | 0 | 11,708 | 3,342,693 |
| 160-169 | 849,226 | 0 | 114,480 | 0 | 963,705 |
| 170-179 | 1,337,317 | 11,434 | 0 | 0 | 1,348,750 |
| 180-189 | 2,124,201 | 0 | 18,905 | 0 | 2,143,107 |
| 190-199 | 2,686,860 | 1,741 | 75,778 | 0 | 2,764,379 |
| 200-299 | 1,444,789 | 0 | 54,801 | 105,008 | 1,604,599 |
| 300 + | 57,835 | 60,549 | 111,358 | 45,275 | 275,017 |
| Total evenaged | 29,091,400 | 794,729 | 6,846,904 | 5,773,842 | 42,506,871 |
| Unevenaged | | | | | |
| < 100 | 0 | 483,798 | 3,940,502 | 2,891,466 | 7,315,767 |
| 100+ | 0 | 359,850 | 2,451,172 | 2,069,254 | 4,880,275 |
| Total unevenaged | 0 | 843,648 | 6,391,674 | 4,960,720 | 12,196,042 |
| Nonstocked* | 219,173 | 1,035 | 43,966 | 52,477 | 316,650 |
| Total, all-aged | 29,310,573 | 1,639,412 | 13,282,544 | 10,787,039 | 55,019,563 |

*0 = none found*

**Nonstocked areas are stocked with less than 10 percent of live trees*

*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

## Distribution of growing stock volume on timberlands by age class and stand structure (all ownerships)

Growing stock volume for evenaged stands can be plotted to show the distribution of volume by decadal age class group. Unevenaged stands by definition generally do not allow this characterization since they contain trees of all ages, and the average age of a stand does not reflect the composition of its volume. Unevenaged stands can be plotted to show the distribution of volume by using the larger range of 100-year increments.

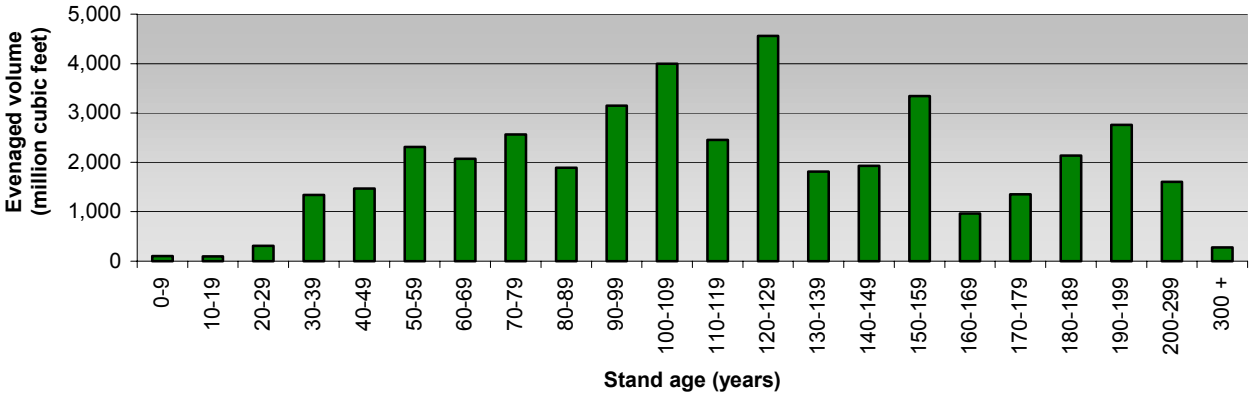
***Over 33 percent of evenaged growing stock volume exists in stands greater than 140 years old. Less than 18 percent of the volume exists in stands less than 70 years old.***

Table 8 summarzied the proportions of evenaged and unevenaged growing stock volume. Just over 77 percent of total growing stock volume is comprised of evenaged timberlands. Unevenaged stands constitute just over 22 percent of total growing stock volume.

Figures 11 and 12 summarize the information found in Table 7 regarding the estimated volume by age class distribution of evenaged and unevenaged timberlands in California. Evenaged stands consist of approximately 18 percent growing stock volume less than 70 years old, 48 percent between 70 and 140

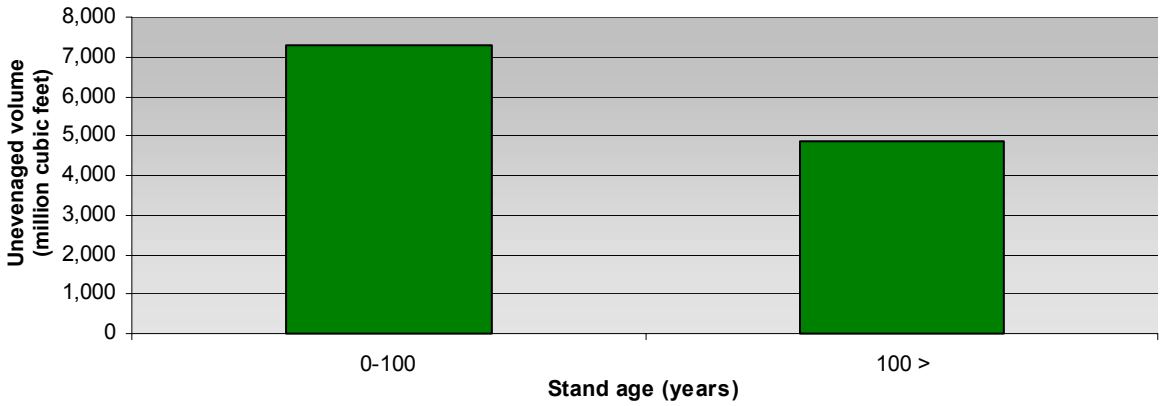
years old, and 33 percent greater than 140 years old. The majority of unevenaged volume exists in stands less than 100 years old.

Figure 11. Volume of evenaged growing stock by age class, all owners, 1994




*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

Figure 12. Volume of unevenaged growing stock by age class, all owners, 1994

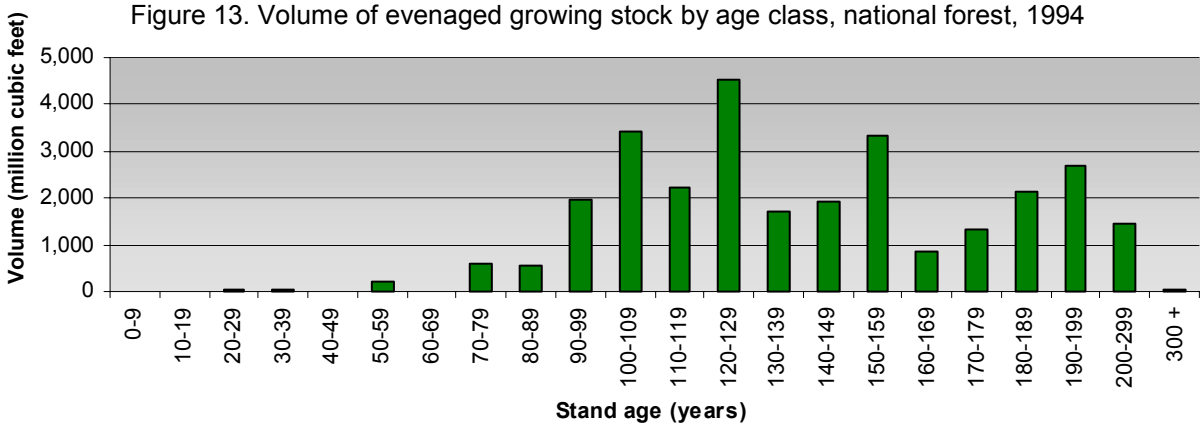



*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

## Distribution of growing stock volume on timberlands by age class and stand structure (national forest ownership)

National forest lands consist of greater proportions of growing stock in older age classes than other ownership classes. Over 98 percent of the growing stock volume exists in age classes greater than 70 years old and over 47 percent in classes greater than 140 years old (Figure 13). Unevenaged stands were not classified on national forest lands.

Figure 13. Volume of evenaged growing stock by age class, national forest, 1994

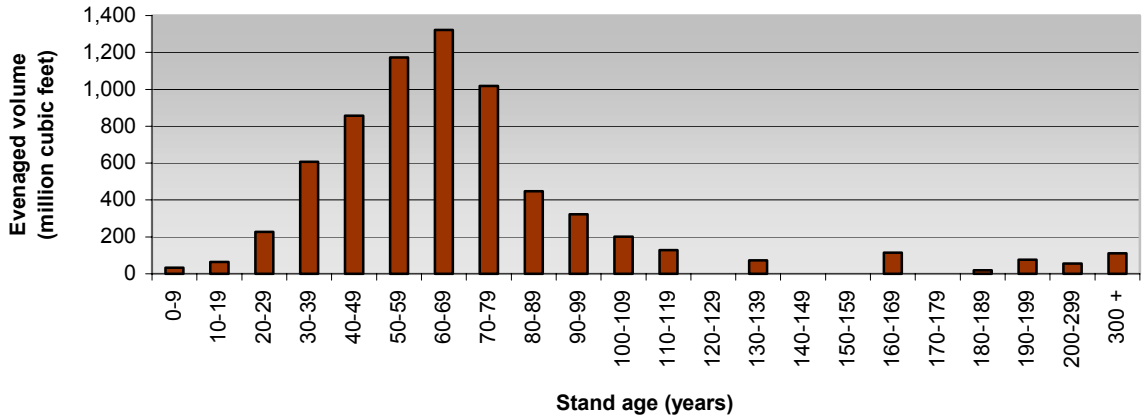



*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

## Distribution of growing stock volume on timberlands by age class and stand structure (forest industry ownership)

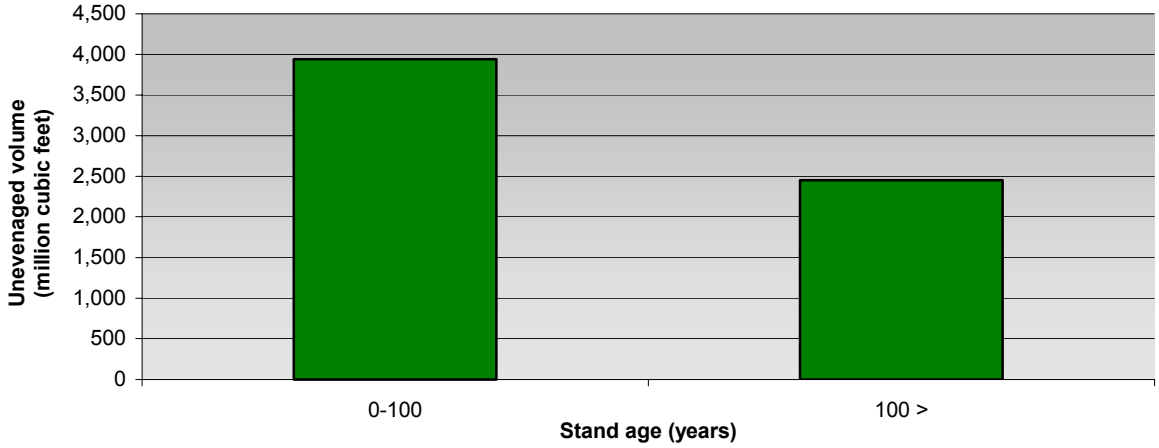
Growing stock volume on timberlands owned by the forest industry can be found in both unevenaged and evenaged stands. The volume in both unevenaged and evenaged stands is nearly equal. The forest industry maintains a different age composition than other ownerships within the State. Because of traditionally intensive management, age classes in evenaged timberlands on these lands are much younger than in other ownerships. Nearly 76 percent of forest industry growing stock volume exists in evenaged and unevenaged stands less than 100 years old (Figures 14 and 15).

Figure 14. Volume of evenaged growing stock by age class, forest industry, 1994




*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

Figure 15. Volume of unevenaged growing stock by age class, forest industry, 1994




*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

## Regional distribution of growing stock volume by age classes and owner

Regional differences can be found in volumes across broad age class groups. This information helps define the characteristic stand volume by age for each resource area. By determining the profile of growing stock volume by age group, evaluations of a region's future timber supply can be formulated.

As shown in Table 9, 58 percent of California's total growing stock inhabits the 100 plus year age classes, 35 percent the 50 to 100 year classes, and seven percent the zero to 50 year classes. Volume in the 100 plus year age classes is far less in the Central Coast and North Coast resource areas while far greater in other resource areas. This statistic suggests that the growing stock volume of older trees is concentrated in the Sacramento, San Joaquin, and North Interior resource areas.

Table 9. Volume of growing stock by owner and age class group by FIA resource area and statewide(thousand cubic feet)

| Resource area and age group | National forest | Other public | Forest industry | Other private | All owners | Percentage of age class |
|---|---|---|---|---|---|---|
| Central Coast | | | | | | |
| 0-49 and nonstocked | 0 | 1,035 | 0 | 16,157 | 17,192 | 1 |
| 50-99 and uneven <100 | 9,625 | 18,551 | 156,316 | 947,572 | 1,132,063 | 59 |
| 100-300+ and uneven >100 | 219,356 | 0 | 0 | 551,097 | 770,453 | 40 |
| North Coast | | | | | | |
| 0-49 and nonstocked | 0 | 73,134 | 1,594,546 | 953,384 | 2,621,064 | 19 |
| 50-99 and uneven <100 | 144,406 | 590,841 | 2,945,948 | 2,804,859 | 6,486,057 | 47 |
| 100-300+ and uneven >100 | 2,942,093 | 203,854 | 638,031 | 856,900 | 4,640,876 | 34 |
| North Interior | | | | | | |
| 0-49 and nonstocked | 67,080 | 9,978 | 170,914 | 110,141 | 358,111 | 2 |
| 50-99 and uneven <100 | 1,083,467 | 163,953 | 2,981,651 | 927,625 | 5,156,696 | 30 |
| 100-300+ and uneven >100 | 10,162,691 | 139,595 | 1,068,237 | 353,092 | 11,723,615 | 68 |
| Sacramento | | | | | | |
| 0-49 and nonstocked | 169,604 | 3,131 | 51,858 | 203,504 | 428,095 | 3 |
| 50-99 and uneven <100 | 1,560,974 | 202,584 | 1,810,179 | 1,360,955 | 4,934,690 | 35 |
| 100-300+ and uneven >100 | 6,560,485 | 92,289 | 1,302,519 | 633,723 | 8,589,014 | 62 |
| San Joaquin and Southern | | | | | | |
| 0-49 and nonstocked | 87,731 | 10,760 | 13,207 | 96,307 | 208,006 | 3 |
| 50-99 and uneven <100 | 513,905 | 115,902 | 329,098 | 642,548 | 1,601,454 | 20 |
| 100-300+ and uneven >100 | 5,789,156 | 13,805 | 220,040 | 329,175 | 6,352,176 | 78 |
| Statewide | | | | | | |
| 0-49 and nonstocked | 324,415 | 98,038 | 1,830,525 | 1,379,493 | 3,632,468 | 7 |
| 50-99 and uneven <100 | 3,312,377 | 1,091,831 | 8,223,192 | 6,683,559 | 19,310,960 | 35 |
| 100-300+ and uneven >100 | 25,673,781 | 449,543 | 3,228,827 | 2,723,987 | 32,076,134 | 58 |

*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

## Findings on softwood timberland volume by size class

Most of California softwood growing stock (95 percent) is classified as "sawtimber" or greater than nine inches DBH (Table 10).

Table 10. Volume of softwood growing stock on timberlands by size class by FIA resource area and statewide, all owners, (million cubic feet)

| Resource area | Sawtimber (>9" DBH) | Poletimber (5" to 9" DBH) | Seedling/Sapling (<5" DBH) | All sizes |
|---|---|---|---|---|
| Central Coast | 1,037 | 10 | 4 | 1,173 |
| North Coast | 8,886 | 206 | 78 | 9,181 |
| North Interior | 15,666 | 728 | 61 | 16,479 |
| San Joaquin Valley | 7,472 | 26 | 25 | 7,568 |
| Sacramento Valley | 11,940 | 755 | 44 | 12,739 |
| Statewide | 45,001 (95%) | 1,725 (4%) | 212 (1%) | 47,140 |

*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

A review of percentages and volume by size class group reveals that over 35 percent of California growing stock volume exists in trees greater than 29 inches DBH (Table 11). From a regional perspective, the percentage of timberland growing stock volume greater than 29 inches in the San Joaquin/Southern and Central Coast resource areas is substantially different than the rest of the State. Well over 40 percent

of the volume in these two resources areas exists in the larger size class, as compared to 35 percent for the State as a whole.

Table 11. Percentage of growing stock volume on timberland by diameter class by FIA resource area and statewide, all owners, 1994

| Diameter class (inches DBH) | Central Coast | North Coast | North Interior | Sacramento | San Joaquin/Southern | Statewide |
|---|---|---|---|---|---|---|
| 5.0-8.9 | 3 | 8 | 8 | 6 | 4 | 7 |
| 9.0-12.9 | 8 | 12 | 13 | 10 | 7 | 11 |
| 13.0-16.9 | 11 | 12 | 14 | 12 | 11 | 13 |
| 17.0-20.9 | 12 | 13 | 14 | 13 | 11 | 13 |
| 21.0-28.9 | 22 | 22 | 21 | 24 | 23 | 22 |
| 29.0+ | 43 | 34 | 30 | 35 | 44 | 35 |

*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

## Findings on timberland growth, mortality, and harvesting rates

### Annual growth and growth rates

The total net annual growth during 1994 (growth less the mortality during the same year) was estimated at 1.3 billion cubic feet (Table 12). This represents a 2.4 percent annual growth rate during 1994. While most ownerships experienced similar growth, the growth rate of the forest industry was substantially higher than other ownerships, growing at 90 cubic feet per acre or an annual rate of 2.8 percent. This is likely the result of the large portions of highly productive land in private ownership, as well as intensively managed, younger-aged growing stocks.

Table 12. Total net volume of growing stock, annual growth and growth rate on timberlands, all species, by owner, 1994 (thousand cubic feet)

| | National forest | Forest industry | Other private | Other public | All owners |
|---|---|---|---|---|---|
| Net volume of growing stock | 29,311,000 | 13,283,000 | 10,787,000 | 1,640,000 | 55,021,000 |
| Current net annual growth of growing stock | 641,098 | 378,290 | 250,799 | 33,363 | 1,303,550 |
| Annual growth per acre (cubic feet) | 73 | 90 | 77 | 78 | 78 |
| Growth rate (annual growth as a percentage of total growing stock) | 2.2 | 2.8 | 2.3 | 2.0 | 2.4 |

*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

In comparing actual growth to the innate ability of the land to growth wood, called "potential growth" (see sidebar below), most ownership on a statewide basis grow about 70 to 75 percent of the growth potential of their land (Table 13). This finding suggests several key points:

- Timberlands occupied by hardwoods likely grow less volume than if occupied by softwoods
- Most ownerships are underutilizing the growing capability of their lands, although this practice may be appropriate based upon biodiversity rational;
- Natural conditions are complex requiring additional investments to increase production beyond current levels;
- Forest industry's use of its land's growing capabilities is no greater than the statewide average, perhaps reflecting cost effectiveness rational or regulatory limitation.

Table 13. Annual and potential growth of growing stock, all species on timberlands by ownership (cubic feet per acre/year)

| Ownership | Net annual growth | Annual growth potential | Annual growth as a percentage of growth potential |
|---|---|---|---|
| National forest | 73 | 97 | 75 |
| Forest industry | 90 | 120 | 75 |
| Other private | 77 | 103 | 75 |
| Other public | 78 | 112 | 69 |
| All owners | 78 | 104 | 75 |

*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

**Actual growth rates and potential growth rates of all species forest types**: Many factors such as soil type, precipitation, insects and pest levels, and species composition affect the growth rate of trees. Each ownership maintains an inherent growth potential or maximum tree growth that could be expected given site conditions (soil). National forest lands possess the lowest growth potential at 97 cubic feet per acre, per year, while forest industry lands possess the highest at 120 cubic feet per acre, per year. However, no ownership can fully utilize its full, inherent growing capability. Even the most productive and well-managed forests in the Pacific Northwest use about 85 percent of the land base's growing potential.

## Mortality rates

Mortality is the amount of volume that died between two measurement periods. A common goal of most forest managers is to maintain healthy forests so that mortality will be low and growth rates high. Mortality agents such as dwarf mistletoe, root disease, and insects can attack slow growing trees and will typically kill them. Windstorms, lightning, and wildfire are examples of mortality agents that are often impossible to control and will kill both healthy and slow growing trees (Bolsinger et al., 1997).

California's average annual mortality of softwood growing stock volume reached 318 million cubic feet in 1994 (Table 14). Losses due to softwood mortality are the focus since softwood volume is most important to State timber production. The national forest class led all ownerships in annual mortality with losses of 153 million cubic feet. Forest industry experienced the highest annual mortality rate at 0.66 percent while the national forest class had the lowest at 0.52 percent.

From a regional perspective, the Sacramento resource area had the greatest softwood mortality, losing 116 million cubic feet or nearly 1 percent of total softwood volume. The Central Coast region experienced the least, losing two million cubic feet (0.15 percent) (Table 14).

Table 14. Average annual mortality and percentage mortality of growing stock on timberland by ownership by FIA resource area and statewide, 1994, (thousand cubic feet)

| | National forest | | Forest industry | | Other private | | Other public | | All owners | |
|---|---|---|---|---|---|---|---|---|---|---|
| Region | Mortality | Percentage total stock | Mortality | Percentage total stock | Mortality | Percentage total stock | Mortality | Percentage total stock | Mortality | Percentage total stock |
| North Coast | 7,193 | 0.23 | 20,553 | 0.40 | 23,459 | 0.51 | 2,806 | 0.32 | 54,012 | 0.39 |
| North Interior | 39,718 | 0.35 | 24,463 | 0.58 | 7,959 | 0.57 | 1,878 | 0.60 | 74,017 | 0.43 |
| Sacramento | 69,095 | 0.83 | 35,001 | 1.11 | 17,615 | 0.80 | 2,630 | 0.88 | 124,342 | 0.89 |
| Central Coast | N/A | N/A | 674 | 0.43 | 4,561 | 0.30 | 24 | 0.12 | 5,259 | 0.31 |
| San Joaquin/ Southern | 37,368 | 0.58 | 7,127 | 1.27 | 14,530 | 1.36 | 1,872 | 1.34 | 60,897 | 0.75 |
| Statewide | 153,374 | 0.52 | 87,818 | 0.66 | 68,124 | 0.63 | 9,210 | 0.56 | 318,527 | 0.58 |

*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

Mortality trends have been of focus recently as it is often referred to as a component of forest health. Mortality varies within ranges, except when periodic catastrophes occur. Total average annual levels have generally been increasing since the low of 1976 (Table 15). Every ownership groups has shown substantial increases in mortality since 1976 (Smith et al., 2001).

Table 15. Annual mortality of growing stock on timberland in the Pacific Southwest (California and Hawaii) region by ownership group and species group (thousand cubic feet), 1952, 1962, 1986, 1996

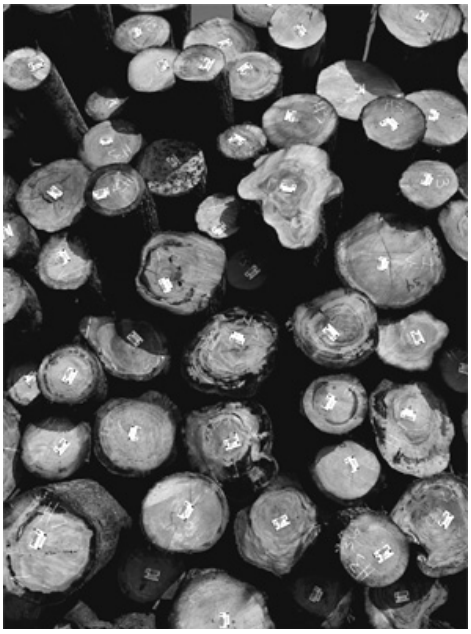
| Owner | 1952 | 1962 | 1976 | 1986 | 1996 |
|---|---|---|---|---|---|
| National forest | | | | | |
| Softwoods | 199,500 | 198,100 | 80,800 | 171,205 | 151,846 |
| Hardwoods | 7,400 | 7,000 | 2,300 | 5,217 | 2,174 |
| Total | 206,900 | 205,100 | 83,100 | 176,422 | 154,020 |
| Other public | | | | | |
| Softwoods | 16,500 | 12,800 | 5,100 | 6,395 | 6,002 |
| Hardwoods | 300 | 300 | 870 | 2,399 | 3,381 |
| Total | 16,800 | 13,100 | 5,970 | 8,794 | 9,383 |
| Forest Industry | | | | | |
| Softwoods | 53,500 | 48,000 | 20,600 | 29,539 | 52,939 |
| Hardwoods | 1,100 | 1,500 | 1,700 | 5,280 | 13,976 |
| Total | 54,600 | 49,500 | 22,300 | 34,819 | 66,915 |
| Nonindustrial private | | | | | |
| Softwoods | 97,300 | 87,200 | 31,200 | 40,665 | 52,319 |
| Hardwoods | 1,300 | 1,400 | 1,922 | 11,420 | 32,232 |
| Total | 98,600 | 88,600 | 33,122 | 52,085 | 84,550 |
| All owners | | | | | |
| Softwoods | 366,800 | 346,100 | 137,700 | 247,804 | 263,106 |
| Hardwoods | 10,100 | 10,200 | 6,792 | 24,316 | 51,763 |
| Total | 376,900 | 356,300 | 144,492 | 272,120 | 314,869 |

*Source: compiled by FRAP from Smith et al., 2001*

## Harvesting trends

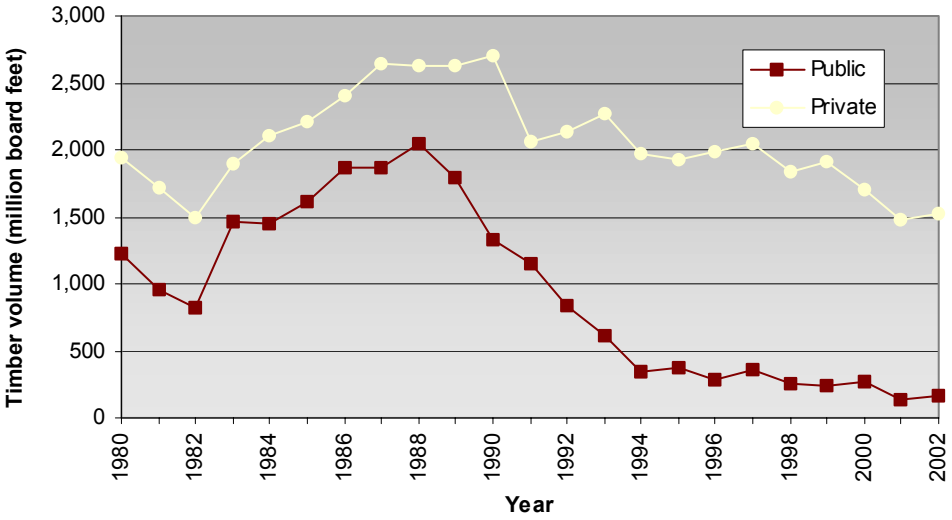
Timber harvesting has long been a fundamental practice on California timberlands and has shaped today's growing stock conditions. Figure 16 indicates historical harvest trends. While most of the information on timber harvesting trends and statistics are summarized in the Assessment document Forest Products Industry, a brief outline follows to help determine the level of growth versus harvest. Montreal Process indicator 12 defines this relationship (annual level of wood products compared to the volume determined to be sustainable).

Timber harvesting in California has steadily declined since the 1988 high of 4.6 billion board feet to 1.6 billion board feet in 2001. The sharp drop is generally the result of public harvest declines reflecting a change in management emphasis away from timber harvesting towards biodiversity objectives.



*Log deck. Photo courtesy of UC Forest Products Laboratory.*

Figure 16. Volume of timber harvested on public and private land, 1978-2002




*Source: compiled by FRAP from California State Board of Equalization, 2003*

## Timberland growth and harvesting on private lands by resource area, 1984 to 1994

A fundamental measure of forest ecosystem condition would include a comparison of forest growth versus harvesting. When growth exceeds harvest, certain ecological functions, habitat components, and timber supply availabilities are often sustained and improved. Examples of habitat components include forest cover continuity and a variety of tree species, ages, and sizes. Ecological functions include large-scale watershed protection through retention of vegetation cover, a biological element that intercepts and filters precipitation.

While excess growth is generally desirable in order to maintain ecological conditions and an adequate supply of timber products, this activity should not be interpreted as the sole indicator of desirable ecological conditions. The relationship between an increasing board foot inventory and stable or improving ecological conditions contains much variation. Excess growth conditions do not address variables such as the spatial array of trees or the quantity and distribution of habitat elements in the forest (snags, down logs). Additionally, a lack of harvesting can result in detrimental forest conditions such as build-up of unnatural levels of fuel in the absence of recurring fire.

A method used to evaluate sustainable forest management is the comparison of periodic growth verses periodic harvest as described in FIA statistics. FIA information provides estimates of the total growing stock volume since 1984 and measures changes due to growth, mortality, and harvest removal since 1994 (Table 16).

Table 16. Decadal growth and harvest by owner and resource area, 1984 to 1994 (million cubic feet)

| Resource area | Forest industry | Other private | Other public | Total |
|---|---|---|---|---|
| **Periodic growth** | | | | |
| North Coast | 1,854 | 1,283 | 228 | 3,365 |
| North Interior | 1,414 | 418 | 73 | 1,905 |
| Sacramento Valley | 902 | 581 | 70 | 1,553 |
| Central Coast | 61 | 334 | (L) | 395 |
| San Joaquin/Southern | 159 | 209 | 6 | 374 |
| Total | 4,390 | 2,825 | 377 | 7,592 |
| **Periodic harvest removals** | | | | |
| North Coast | 2,198 | 193 | 96 | 2,487 |
| North Interior | 786 | 165 | (L) | 951 |
| Sacramento | 815 | 158 | 51 | 1,024 |
| Central Coast | 6 | 104 | (L) | 110 |
| San Joaquin/Southern | 121 | 178 | 6 | 305 |
| Total | 3,926 | 798 | 153 | 4,877 |

*(L) – less than 500,000 cubic feet or none*

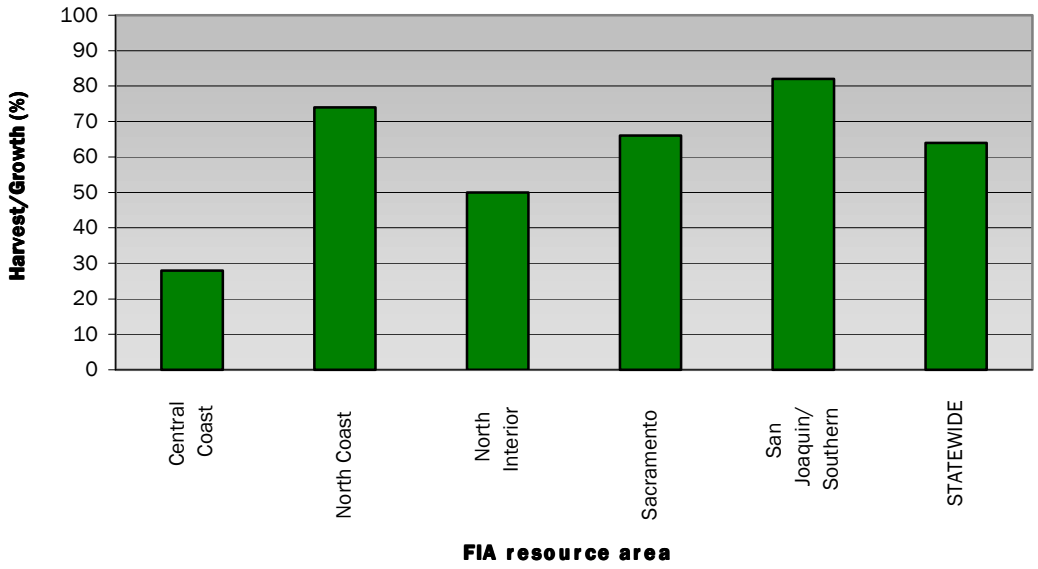
*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

A ratio of harvest divided by net growth summarizes this information. This measurement is employed in Figure 17 to portray California's private timberland in five FIA resource areas over a 10-year period (1984 to 1994). The measurement is developed by dividing harvests by total growth in millions of cubic feet (minus total mortality) during the period for softwood and hardwood forest types. A percentage of 100 indicates that net growth equaled harvest for the period.

***On the California's private timberlands, harvests are 64% of net growth between 1984 and 1994.***

Over the period of 1984 to 1994, harvest volume was 64 percent of growth on private timberlands for all FIA resource areas (Figure 17). However, harvest as a percentage of growth varied by resource area. The San Joaquin/Southern and North Coast resource areas had harvests most closely equaling growth. These findings suggest that the State's forest ecosystems are producing more volume than is being harvested.

Figure 17. Harvest as a percentage of growth on private timberlands by resource area and statewide, 1984-1994




*Source: compiled by FRAP from Waddell and Bassett, 1996, 1997a, 1997b, 1997c, and 1997d*

## Findings on projected growing stock

USFS economists project that total U.S. timber growing stock inventory will continue to expand into 2050, particularly in the western and southern regions of the United States. Softwood growing stock inventory is projected to increase by 50 percent in the western and southern United States by this target date. While western inventory declined between 1952 and 1990, it is now growing. By 2050, the West is projected to account for 68 percent of the U.S. softwood inventory while the South is projected to account for two percent. By 2050, hardwood growing stock inventory is projected to drop slightly in the South while increasing 44 percent in the North region (Haynes, 2002) (see Timber Situation in the United States: 1952 to 2050).

## Glossary

**board foot:** A unit of measure that is equal to a section of lumber that is 12 inches wide by one inch thick by 12 inches long and used in forestry to estimate the amount of sawn boards that can be generated from a tree bole.

**bole:** The trunk of a tree, below the lowest branch.

**conifer:** Trees belonging to the order Gymnosperm, comprising a wide range of trees that are mostly evergreens. Conifers bear cones and have needle-shaped or scalelike leaves. In the wood products industry the term "softwoods" refers to the conifers.

**cubic foot:** A measurement used in forestry to estimate the volume of wood material that can be generated from a tree bole or entire tree. It equals a volume of wood one foot long by one foot high by one foot wide.

**cutblock:** A specific area of land within which timber is to be or has been harvested; may be used in reference to timber harvest plans or other forest planning documents in California.

**DBH:** See **diameter at breast height**.

**decadal:** Pertaining to ten; consisting of tens, particularly ten years; by decade.

**diameter at breast height:** Tree trunk diameters are measured at breast height, defined as the diameter of the tree 4.5 feet (1.37 m) above ground on the uphill side of the tree.

**disturbance regime:** A natural or human caused event like floods, fire, and storms that shape vegetative composition and seral stage.

**evenaged:** A forest stand or forest type in which relatively small (10-20 year) age differences exist between individual trees. Evenaged stands are often the result of fire, or a harvesting method such as clearcutting or the shelterwood method.

**evenaged stand:** Forest stand where more than 70 percent of the tree stocking falls within three adjacent decadal age classes.

**FIA:** See **Forest Inventory and Analysis**.

**The Forest and Rangeland Renewable Resources Planning Act of 1974:** An assessment of the nation's renewable resources every 10 years conducted by the U.S. Forest Service.

**Forest industry:** Lands owned by companies that grow timber for commercial use. Includes companies both with and without wood processing plants; An ownership class in the USDA FS PNW Experiment Station Forest Inventory and Analysis program.

**Forest Inventory and Analysis:** Forest land and timberland statistics reported by the Pacific Resource Inventory, Monitoring and Evaluation program (PRIME) of PNW. Every decade, PRIME conducts the Forest Inventory and Analysis, which is a national mandate authorized by the Forest and Rangeland Renewable Resource Research Act of 1978. The FIA is a plot-based survey and statistical analysis with representative field based plots of all forest lands outside the National Forest System.

**FRAP:** Fire and Resource Assessment Program.

**growing stock:** Represents the bole wood of forest trees greater than five-inches DBH.

**hardwoods:** Dicotyledonous trees; trees that are generally deciduous, broad-leafed species such as oak, alder, or maple.

**Montreal Process:** A scientifically rigorous set of criteria and indicators used to measure forest management and sustainability.

**national forest:** Federal lands that have been designated by Executive Order or statute as national forest or purchase units and other lands under the administration of the U.S. Forest Service.

**Other Private:** Private lands not owned by forest industry; an ownership class in the USDA FS PNW Experiment Station Forest Inventory and Analysis program.

**pioneer species:** The first plants and animals to colonize a new habitat. Pioneer species are typically opportunistic species that can quickly inhabit the area. They have great dispersal capabilities, as well as an ability to reproduce rapidly and abundantly.

**PNW:** Pacific Northwest Research Station.

**productive capacity:** The ability of an ecosystem to produce the raw materials necessary for economic activities. These materials include all renewable resources found both on and below the surface of the ecosystem such as agricultural products, fibers, foodstuffs, timber, water, etc.

**reforestation:** The natural or artificial restocking (i.e., planting, seeding) of an area with forest trees.

**RPA:** See **The Forest and Rangeland Renewable Resources Planning Act of 1974**.

**sawtimber:** Live trees of commercial species containing at least one 12' sawlog or two noncontiguous 8' logs. Softwoods must be at least 9" in diameter and hardwoods at least 11" in diameter.

**silviculture:** Generally, the science and art of cultivating (such as with growing and tending) forest crops, based on the knowledge of silvics. More explicitly, silviculture is the theory and practice of controlling the establishment, composition, constitution, and growth of forests.

**site class:** an internal into which a measurement of the trees' trunk diameters at breast height (DBH) is divided for classification e.g., two-inch size classes.

**softwoods:** Coniferous trees, usually evergreen, having leaves that are needles or scale like.

**stand:** A group of trees sufficiently uniform in composition, age, and/or condition as to form a management entity and distinguishable from adjoining groups of trees.

**timberland:** Forest land capable of growing 20 cubic feet or more of industrial wood per acre per year (mean increment at culmination in fully stocked, natural stands). Timberland is not in a reserved status through removal of the area from timber utilization by statute, ordinance, or administrative order and is not in a withdrawn status pending consideration for reserved.

**understory:** The trees and other woody species growing under a relatively continuous cover of branches and foliage formed by the overstory trees.

**unevenaged:** Silvicultural system in which individual trees originate at different times and result in a forest with trees of many ages and sizes; stands where less than 70 percent of the tree stocking falls in three adjacent 10 year age classes.

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